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Indian Standard

RECOMMENDED PROCEDURE FOR REPAIR WELDING OF STEEL COMPONENTS BY ALUMINO-THERMIC PROCESS

UDC 621·791·65 : 669·14 - 42 : 006·76

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INDIAN STANDARDS INSTITUTION
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

October 1980

AMENDMENT NO. 1 APRIL 2007
TO
IS 9524 : 1980 RECOMMENDED PROCEDURE FOR REPAIR WELDING OF STEEL COMPONENTS BY ALUMINO-THERMIC PROCESS

(*Page* 3, *clause* 0.3, *last line* & *clause* 0.4, *line* 6) — Substitute 'T19-1994' *for* 'T19-65'.

(*Page* 4, *clause* 4.2, *line* 2) — Substitute 'Scavenger' *for* 'scaverger'.

(*Page* 5, *clause* 4.3.1, *line* 2) — Incorporate the following in between the words 'chips' and 'to':

'to reduce the temperature of super heated molten steel to about 2 100°C.'

(*Page* 5, *clause* 4.4, *line* 6) — Substitute '0.015 and 0.65' *for* '0.30 and 0 70'.

(*Page* 5, *clause* 4.4, *line* 7) — Substitute '0.65' *for* '0 70'.

(*Page* 5, *clause* 4.4, *line* 8) — Substitute '0.15' *for* '0 30'.

(*Page* 12, *Table* 2, *Title*) — Add the word 'MIXTURE' in between the words 'THERMIT' and 'REFERRED'.

(*Page* 14, *clause* 8.1) — Add the following at the end of the clause:

'For preheating of the job the following method may be adopted. At present there are three different systems:

i) Use of air-petrol mixture through drum vaporizer,
ii) Use of compressed air-petrol mixture through burner, and
iii) Use of oxygen and LPG gas mixture through special type of preheating torch.'

(*Page* 15, *clause* 9.2, *first sentence*) — Substitute the following for the existing:

'The reaction shall be started by a suitable ignition method such as insertion of ignition device (sparkler) in the thermit mixture.'

(*Page* 15, *clause* 12.1) — Substitute the following for the existing clause:

'Wherever possible the welds should be subjected to suitably qualified non-destructive methods to ensure freedom from defects. The acceptance limit for the flaws shall be mutually agreed between the user and manufacturers.'

(*Page* 15, *clause* 13.1, *second line*) — Incorporate the following in between the words 'be' and 'adequately':

'educated at least up to Secondary School (high school/matriculation pass) or having ITI certificate or equivalent and'

(MTD 12)

Reprography Unit, BIS, New Delhi, India

Indian Standard

RECOMMENDED PROCEDURE FOR REPAIR WELDING OF STEEL COMPONENTS BY ALUMINO-THERMIC PROCESS

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(*Continued on page* 2)

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(*Continued on page* 16)

Indian Standard

RECOMMENDED PROCEDURE FOR REPAIR WELDING OF STEEL COMPONENTS BY ALUMINO-THERMIC PROCESS

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 26 May 1980, after the draft finalized by the Welding General Sectional Committee had been approved by the Structural and Metals Division Council.

0.2 Alumino-thermic welding (thermit welding*) comprises of a group of welding processes wherein coalescence is produced by heating with superheated liquid metal and slag resulting from a chemical reaction between a metal oxide and aluminium, with or without the application of pressure. Filler metal, when used, is obtained from the liquid metal.

0.3 Thermit welding is increasingly used to fabricate large metal pieces, for joining rails, and reinforcing bars. Simple forgings and small castings are thermit welded into heavier units to reduce the cost substantially. The process is also used to repair heavy castings, shafts, etc. This standard is intended to be a guide for the use of thermit welding process for fusion welding for ferrous metals other than rails for which a separate Indian Railways Standard Specification No. T-19-65 exists.

0.4 This standard keeps in view the practices being followed in the country in this field. Assistance has also been derived from the following publications:

Welding Handbook Section 3 B 'Welding cutting and related processes' American Welding Society, USA.

IRS T 19-1965 'Fusion welding of rails by alumino-thermic process' Ministry of Railways, Government of India.

0.5 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS : 2-1960†. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

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*The term 'thermit welding' is used throughout this standard for the sake of convenience and uniformity.

†Rules for rounding off numerical values (*revised*).

1. SCOPE

1.1 This standard recommends the procedure for repair welding of steel components by alumino-thermic process.

2. TERMINOLOGY

2.1 For the purpose of this standard the definitions given in IS : 812-1957* shall apply.

3. PRINCIPLE OF THE PROCESS

3.1 Alumino-thermic welding (thermit welding) is based on the exothermic reaction between finely divided aluminium and iron oxide.

The chemical reaction of the process may be expressed by the following formulae:

$$3FeO + 2Al = Al_2O_3 + 3Fe + 0{\cdot}78\ \text{MJ}\ (\ 187{\cdot}1\ \text{kcal}\ )$$
$$Fe_2O_3 + 2Al = Al_2O_3 + 2Fe + 0{\cdot}76\ \text{MJ}\ (\ 181{\cdot}5\ \text{kcal}\ )$$
$$3Fe_3O_4 + 8Al = 4Al_2O_3 + 9Fe + 3{\cdot}01\ \text{MJ}\ (\ 719{\cdot}3\ \text{kcal}\ )$$

The iron which is set free in highly superheated state, immediately transforms into molten steel, while Al_2O_3 formed separates as highly superheated molten slag.

3.2 The temperature of the reaction is not measurable by any mechanical instrument, but it has been theoretically determined to be about 3 000°C (neglecting the losses). In practice this temperature is reduced to about 2 100°C by the addition of metal chips and alloys and also due to general loss of heat by radiation and conduction. This leaves the metal about 600°C of superheat to effect the welding of parts.

4. THERMIT MIXTURE

4.1 Plain thermit is a mixture of iron oxide and finely divided aluminium. This is the basis of most thermit mixtures and it yields very high temperatures.

4.2 Carbon Steel Thermit — This is plain thermit with addition of steel chips and the ingredients as grain refiner, scaverger, alloying elements, etc, to suit the chemistry and the mechanical properties of parts to be welded.

---

*Glossary of terms relating to welding and cutting of metals.

4.3 Cast Iron Thermit

4.3.1 This is plain thermit with additions of ferro silicon to promote graphitization and steel chips to augment metal production. Unless the welded joint and its adjacent area are given a post-weld heat treatment, this weld metal is generally non-machinable. Because of differential contraction between the weld metal and the cast iron base metal, use of this thermit mixture is limited to weld cast iron where the length is less than eight times its width.

4.3.2 Another thermit that will yield deposits of an average cast iron weld metal analysis is used when it is necessary to have a machinable weld metal or when the length to width ratio of the component is greater than eight. This thermit mixture throws out graphitic carbon at the grain boundaries to a degree that depends upon the cooling rates. Weld metal contraction upon cooling is usually neglegible.

4.4 While formulating the thermit mixtures, care should be taken to add correct quantity of aluminium (deoxidizer) and allowing elements in order to achieve the weld deposit of required chemical composition and physical properties. Precise weights of the constituents are necessary so that after reaction, there remains a small excess of aluminium between 0·30 and 0·70 percent in the thermit steel. When aluminium content exceeds 0·70 percent, the impact properties are badly affected. On the other hand, if it is below 0·30 percent, the thermit steel tends to be hot short and susceptible to porosity. Care should also be taken to ensure that the ratio of carbon to manganese is 1 : 3 *Min.*

4.5 Thermit mixtures which are stable over a period of many years, shall be supplied in moistureproof bags. Ignitors shall be supplied separately. Thermit mixtures should be kept dry. Damp mixtures should not be used. Before use, the mixture shall be thoroughly mixed in the bag itself by inverting the sealed bag several times. In the case of large quantities, each bag of the mixture should be thoroughly mixed up dumping the mixture into a pan or a tray and turning the pile over a number of times before putting into the crucibles.

4.6 The mixture if warmed to the touch of hand will result in smoother and faster reaction than the cold mixture. It is therefore desirable to warm the mixture carefully to drive off the dampness first before dumping it into the thermit crucible.

4.7 The thermit mixtures are non-explosive. No fire hazard is incurred under normal conditions of handling and storing thermit mixtures, since a temperature of more than 1 200°C is required to ignite the mixture.

5. THERMIT CRUCIBLE

5.1 The thermit reaction takes place in crucibles which consist of a conical steel shell lined with magnesite using a suitable binder, for example, sodium silicate solution and covered with a conical steel cap with opening at both the ends and an inspection hole at the side. A typical crucible is illustrated in Fig. 1.

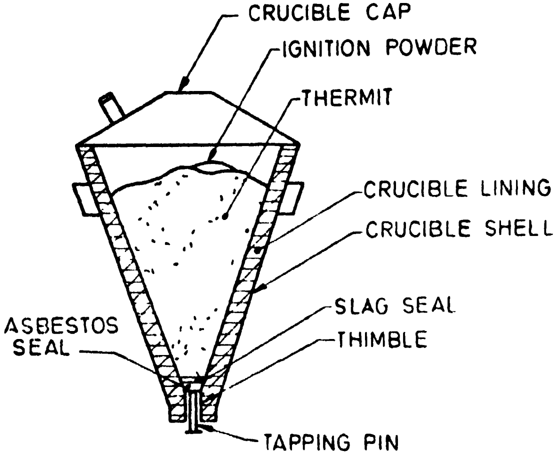

FIG. 1 TYPICAL CRUCIBLE FOR THERMIT WELDING

5.2 At the bottom of the crucible is a magnesite thimble-seat which has a tubular opening plugged by another small magnesite thimble of cylindrical form. This thimble provides a channel through which the liquid thermit steel is poured. The plug thimble can be removed by gently knocking it upward and a new thimble inserted.

5.3 The high temperature together with vigorous ebulition of the molten metal during the reaction necessitates a lining which is not only mechanically strong but of a highly refractory nature. Magnesite as well as thermit slag have been found to be very satisfactory lining materials.

5.4 The crucible is plugged before charging by first inserting the thimble. The tapping pin which temporarily closes the thimble is suspended through the thimble and over this is placed the asbestos powder and thermit slag.

5.5 The crucible stand shall be fabricated so as to position the crucible to suit the job. The tapping hole of the crucible shall be vertically above the centre of the pouring gate. In order to avoid splashing as well as to accommodate tapping pin and spade, a gap not exceeding 150 mm between the tapping hole and top of the pouring gate should be ensured. It is advisable to check the crucible stand for position before preheating the mould so that any necessary modification may be made during preheating.

5.6 Crucible should be baked to make sure that its lining is free from moisture. Presence of moisture in the crucible causes splashing of slag and metal from the crucible during the reaction.

6. PREPARATION OF COMPONENTS PRIOR TO WELDING

6.1 The crack should be extended by suitable means until the component is separated into two parts. The ends shall be cut square. A predetermined gap shall be kept between two parts to be welded depending upon the cross-sectional area. If the parts are of uniform cross-section, joint preparation shall be made by removing metal from either side of the fracture, but if the cross-section is irregular, same amount of metal is removed from both sides of the fracture. The mating faces as well as adjacent surfaces shall be cleaned of any loose scale, slag, dirt, grease or other foreign matter.

6.2 After making an allowance for contraction, the parts to be welded shall be aligned and firmly held onto the jig. The allowance varies from 5 to 8 mm depending upon the size of the weld and the time of preheating. The parts are clamped properly onto the jig with straps and bolts, care being taken to ensure that these bolts can be slackened immediately after welding to allow the part to contract.

6.3 In order to allow for the proper amount of contraction of the weld area, it is desirable, after lining up the parts in preparation for cutting the gap, to place trim marks on the two parts. These marks are made at points outside the area to be covered by the mould box approximately at about 300 mm apart either side of the gap. The metal at the point of weld may then be cut out along the line of fracture with a cutting torch so that a parallel gap is provided.

6.4 Calculation of Weight of Thermit Mixture

6.4.1 The width of the gap depends upon the size of the section to be welded and may be calculated as follows:

$$\text{Width of gap} = \text{Thickness of collar at centre}$$
$$= \sqrt[3]{(\text{area of cross-section in cm}^2)/2.64}$$

$$\text{Width of collar} = 0{\cdot}3 \times \sqrt{(\text{area of cross-section in cm}^2)} + 2 \times \text{width of gap}$$

The volume of the gap should be calculated from the profile of the sections to be welded. The volume of collar can be calculated as follows:

$$\text{Volume of collar} = 0{\cdot}8 \times \text{width of collar} \times \text{thickness of collar} \times \text{circumference of collar}$$

The volume of risers, pouring, heating and connecting gates are also to be added to the volume of collar and gap. After calculating the volume, the weight of thermit mixture is to be calculated, assuming that 1 cm^3 of thermit steel weighs approximately 8·13 g. The mixture required should include provision for a 10 percent excess to meet the contingencies. It is always safe to use an excess amount of thermit mixture for a satisfactory weld. The yield of the steel is about 60 percent.

Tables 1 and 2 show the dimensions of gap, collar riser, heating, pouring and connecting gates as well as the weight of thermit mixture required.

6.4.2 The quantity of thermit mixture can also be calculated from the weights of the wax pattern. By weighing the wax before and after making the pattern, the amount of wax used is determined. For every kilogram of wax used approximately 25 kg of thermit is required. This factor may be reduced in the case of very large repair welds because the percent of metal in the gates and risers decreases.

6.4.3 The calculation of the charge of thermit mixture depends on the chemistry and mechanical properties of the component to be welded. A typical weld metal composition for medium tensile steel component is given below:

C – 0·28%, Mn – 0·85%, Si – 0·45%, Al – 0·42%

7. MOULDS FOR REPAIR WELDING

7.1 The type of mould used depends upon two factors; whether the weld is repetitive or non-repetitive, and whether the parts to be welded are to be pre-heated or not. Repair welds are normally non-repetitive. Some large welds though repetitive in nature, may require the same handling as for non-repetitive welds. Pre-heating may be used economically for non-repetitive welds or where a number of duplicate welds are involved. The two controlling factors are the amount of heat required to produce the weld and the most efficient means of transferring it.

7.2 For non-repetitive welds each mould is made up individually on the part itself. When a single large weld is to be made, a wax pattern is formed on the weld and the process is called ' lost wax process '. The wax used as pattern may be paraffin wax or a mixture with commercial beeswax in the ratio of 2 : 1. The wax is made to fill the gap, and is applied to the surface of the parts in the exact shape desired in the finished weld, including collar. A vent hole is provided by embedding a 6 mm cord through the body of the wax after the mould is complete. A sand mould is then made around the pattern, using a suitable mould box of about 5 mm thick plates to back up sand rammed around the parts.

7.3 The sand mould is made by ramming a small amount around the edges of the box and then in towards the centre. The surface of the mould should be kept level during ramming. The material near the parts to be welded is packed as tightly as possible, since that area of the mould has to resist the pre-heating gases and the subsequent metal flow. Area of the mould towards the outside of the box need not be rammed as tightly. Wooden patterns suitable for pouring and heating gates, are inserted within the mould as it is being rammed. A wooden heating gate pattern is set at the lowest point of the wax. It should lead out to the front of the box where an opening through the mould box plate is provided. Table 3 shows the typical composition and mechanical properties of moulding sand.

7.4 When the two pieces to be welded are of the same size, the heating gate is centered directly on the wax pattern. If however, a light section is being welded to a heavy one, the preheating opening in the mould is directed more towards the heavy section in order to ensure uniform heating of the two parts. A typical mould is shown in Fig. 2.

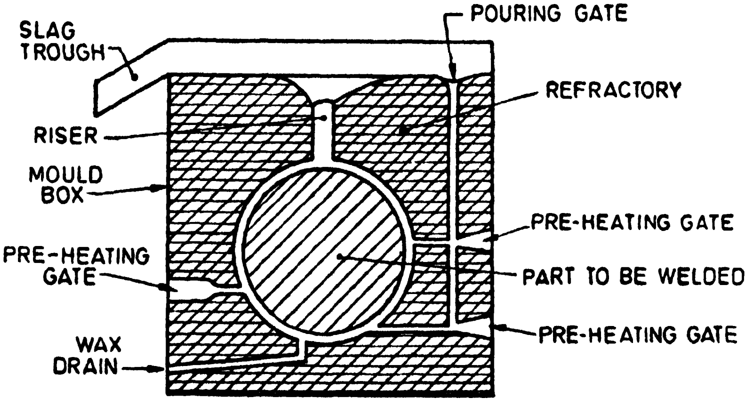

FIG. 2 MOULD FOR JOINING MASSIVE SECTIONS BY THE THERMIT WELDING PROCESS

TABLE 1 THERMIT REPAIR WELD DIMENSIONS AND QUANTITY OF THERMIT MIXTURE REQUIRED FOR RECTANGULAR SECTIONS

(*Clause* 6.4.1)

SECTION WIDTH HEIGHT	GAP	COLLAR DIMENSIONS	RISER		POURING GATES		HEATING GATES		CONNECTING GATES		THERMIT MIXTURE REQUIRED
			No.	Dia	No.	Dia	No.	Dia	No.	Dia	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
mm × mm	mm	mm × mm		mm		mm		mm		mm	kg
50 × 50	12	40 × 12	1	20	1	20	1	32	—	—	2·7
50 × 100	15	30 × 15	1	20	1	25	1	32	—	—	5·4
75 × 75	15	50 × 15	1	25	1	25	1	32	—	—	5·4
75 × 150	18	45 × 18	1	25	1	25	1	32	—	—	11
100 × 100	18	65 × 18	1	25	1	25	1	32	—	—	11
100 × 200	22	90 × 22	1	25	1	25	2*	32	—	—	23
125 × 125	20	90 × 20	1	25	1	25	1	32	—	—	23
125 × 200	24	95 × 24	1	25	1	31	2*	32	—	—	34
150 × 150	24	90 × 24	1	32	1	31	2*	32	—	—	34
150 × 225	26	110 × 26	1	32	1	31	1	32	—	—	45
175 × 175	25	105 × 25	1	38	1	31	2*	32	—	—	45
175 × 250	28	120 × 28	1	50	1	31	1	32	—	—	57
200 × 200	28	115 × 28	1	45	1	31	2*	32	—	—	57
200 × 300	31	125 × 31	1	45	1	32	1	32	31	31	79
225 × 225	30	125 × 30	1	50	1	32	2*	32	—	31	68
225 × 325	35	135 × 35	1	50	1	32	1	32	1	31	102
250 × 250	33	140 × 33	1	55	1	32	1	32	1	31	92
250 × 375	37	165 × 37	1	56	1	37	2*	32	—	—	147
275 × 275	35	150 × 35	1	56	1	37	2*	32	—	31	113
275 × 400	40	180 × 40	1	56	1	37	2*	32	1	31	181
300 × 300	37	160 × 37	1	62	1	37	2*	37	1	37	136
300 × 450	43	200 × 43	1	62	1	37	2*	37	1	37	227

325 × 325	40	175 × 40	1	62	1	37	2*	37	1	37	170
325 × 475	44	205 × 44	1	62	2	37	2*	37	2	37	306
350 × 350	40	190 × 40	1	62	2	37	2	37	2	37	227
350 × 500	45	215 × 45	1	62	2	50	2	37	2	37	303
375 × 375	43	200 × 43	1	70	2	38	2	37	2	37	272
375 × 550	50	235 × 50	1	70	2	50	2	37	2	37	442
400 × 400	45	225 × 45	1	70	2	50	2	37	2	37	318
400 × 600	50	250 × 50	1	70	2	50	2	37	2	37	522
450 × 450	50	230 × 50	2	55	2	50	2	50	2	50	431
450 × 650	55	270 × 55	2	55	2	50	2	50	2	50	692
500 × 500	52	250 × 52	2	55	2	50	2	50	2	50	546
500 × 750	60	300 × 60	2	55	2	50	2	50	2	50	907
550 × 550	55	275 × 55	2	63	2	50	2	50	2	50	703
550 × 800	60	320 × 60	2	63	2	50	2	50	2	50	1 122
600 × 600	58	295 × 58	2	63	2	50	2	44	2	44	850
600 × 900	65	350 × 65	2	62	2	50	2	50	4	50	1 418
650 × 650	62	320 × 62	2	62	2	50	2	50	2	50	1 032
650 × 950	69	375 × 69	2	62	2	50	2	56	4	56	1 678
700 × 700	65	340 × 65	3	62	2	50	2	50	2	50	1 259
700 × 1 050	74	400 × 74	3	62	2	50	2	62	4	62	2 120
750 × 750	68	360 × 68	3	62	2	50	2	56	2	56	1 485
750 × 1 125	77	430 × 77	3	62	2	50	2	62	4	62	2 506

*Includes one separate back heating gate.

TABLE 2 THERMIT REPAIR WELDING DIMENSIONS AND QUANTITY OF THERMIT REFERRED FOR ROUND SECTIONS

(*Clause* 6.4.1)

DIA	GAP	COLLAR	RISER	POURING GATES		HEATING GATES		CONNECTING GATES		THERMIT MIXTURE REQUIRED
			Dia	No.	Dia	No.	Dia	No.	Dia	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
mm	mm	mm × mm	mm		mm		mm		mm	kg
50	12	35 × 12	19	1	19	1	32	—	—	2·3
75	15	45 × 15	25	1	25	1	32	—	—	4·9
100	15	60 × 15	25	1	25	1	32	—	—	11
150	19	70 × 19	32	1	25	1	32	—	—	11
150	22	60 × 22	32	1	25	1	32	—	—	36
175	24	70 × 24	32	1	32	1	32	—	—	34
200	25	105 × 25	37	1	32	1	32	—	—	34
225	28	115 × 28	37	1	37	1	37	—	—	57
250	30	125 × 30	37	1	37	2*	37	—	—	68
275	31	135 × 31	44	1	37	2*	37	—	—	79
300	33	150 × 33	44	1	37	1	37	1	37	91
325	37	160 × 37	44	1	37	1	37	1	37	113
350	37	170 × 37	44	1	37	1	37	1	37	136

375	40	180 × 40	50	1	37	1	37	1	37	159
400	40	190 × 40	50	1	37	1	37	1	37	193
450	44	210 × 44	56	1	50	1	50	1	50	261
500	47	226 × 47	62	1	50	1	50	1	50	476
550	50	250 × 50	69	2	50	2	50	2	50	606
600	53	265 × 53	75	2	50	2	50	2	50	726
650	56	290 × 56	81	2	50	2	50	2	50	874
700	60	305 × 60	81	2	50	2	50	2	50	1 032
750	60	325 × 60	81	2	50	2	50	2	50	1 200

7.5 When the mould is completely rammed, the top is hollowed out to provide a basin for the slag produced by the thermit reaction. A channel is also cut in the surface of this slag basin between the riser and the pouring gate opening. The moulding sand is then troweled away from the top of the pouring gate to provide a larger opening and a shelf onto which the thermit steel can subsequently be tapped. The mould should be vented thoroughly for the escape of moisture during the preheating process and gases after pouring the thermit metal.

TABLE 3 TYPICAL COMPOSITION AND MECHANICAL PROPERTIES OF MOULDING SAND

(*Clause* 7.3)

Chemical Composition		Mechanical Properties	
Constituents	Percentage		
SiO_2	90·2	Green compressive strength	— 0·188 MPa (1·92 kgf/mm^2)
Clay	7·0		
Al_2O_3	5·5	Green shear strength	— 0·06 MPa (0·6 kgf/mm^2)
Fe_2O_3	1·5		
CaO	0·2	Permeability	— 40
MgO	0·2		
Loss at 150°C	7·5		

8. PRE-HEATING

8.1 Most of the repair jobs require pre-heating, which may be carried out by any suitable method. The most common method is by burning a fuel-air mixture within the mould. Pre-heating may also be accomplished by running part of the molten metal from the thermit reaction into direct contact with the parts and overflowing it prior to flowing in the final filler metal.

8.2 Where wax patterns are used, the initial purpose of the pre-heating is to remove the wax. The heat is applied gradually and the burner is frequently removed from the heating gate to allow liquid wax to roll out of that part. Once the wax has been removed, the rate of flow of fuel is increased so that combustion takes place through the mould cavity. The purpose of heating at this time is to give the faces of the base metal an initial pre-heat and to thoroughly dry the mould. Pre-heating to about 900°C is satisfactory. Upon completion of the pre-heat, the gate through which the heat was introduced must be blocked.

9. IGNITING THE CHARGE AND TAPPING THE CRUCIBLE

9.1 When the pre-heating is completed, the crucible is positioned over the mould, the burners are removed, the pre-heating gates quickly plugged with iron rod coated with sand and mud-mixture and the mould positioned ready for pouring. This should be completed very quickly as during this operation pre-heated parts are losing heat. Therefore, all tools such as the tapping spade, spanner, hammer, etc, should be kept ready while pre-heating is carried out.

9.2 The reaction shall be started by touching the mixture with a red hot steel rod. After the reaction is completed, the slag is allowed to float to the top, and the tapping pin is moved upwards allowing the thermit steel to run into the mould through pouring gate. Molten metal rises up through the gap and collar and fills the riser. Slag floats on the top of metal in the pouring gates and spills into the slag basin without entering the mould at all. When the pouring is over, dry sand should be sprinkled over the slag to reduce heat losses and keep the riser molten.

10. COOLING AND FINISHING

10.1 After waiting for 4 to 5 minutes after tapping, the parts should be slackened to allow contraction to take place. The job should be allowed to cool slowly to about 400°C. The risers and the mould are then removed. Pre-heating gates are also removed by flame cutting. The collars may or may not be removed.

11. POST-WELD HEAT TREATMENT

11.1 No post-weld heat treatment is required for welds of small cross-section, but it is desirable to normalise them if the cross-sectional area is more than 325 cm^2. This may be conveniently done by building up a temporary furnace with refractory bricks around the joint and heating to the appropriate temperature.

12. TESTING THE WELDS

12.1 Wherever possible the welds should be subjected to non-destructive tests such as megnetic particle, dye-penetrant, radiography, etc, to ensure freedom from harmful surface as well as internal defects.

13. QUALIFICATION OF THE WELDING PERSONNEL

13.1 The persons engaged in alumino-thermic welding operation should be adequately trained to be capable of producing welds of satisfactory and consistent quality. They should have the knowledge of different foundry materials and methods of making moulds.

13.2 The operators should be instructed to wear dark blue glasses as well as protective clothing to protect themselves from the intense glare and heat from the reaction.

(*Continued from page* 2)

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IS:	
818-1968	Code of practice for safety and health requirements in electric and gas welding and cutting operations (*first revision*)
819-1957	Code of practice for resistance spot welding for light assemblies in mild steel
822-1970	Code of procedure for inspection of welds
1179-1967	Equipment for eye and face protection during welding (*first revision*)
1261-1959	Code of practice for seam welding in mild steel
2811-1964	Recommendations for manual tungsten inert-gas arc welding of stainless steel
2812-1964	Recommendations for manual tungsten inert-gas arc welding of aluminium and aluminium alloys
3016-1965	Code of practice for fire precautions in welding and cutting operations
3023-1965	Recommended practice for building up by metal spraying
4353-1967	Recommendations for submerged-arc welding of mild steel and low alloy steels
4944-1968	Cost of procedure for welding at low ambient temperatures
5139-1969	Recommended procedure for repair of grey iron castings by oxy-acetylene and manual metal arc welding
5530-1969	Code of procedure for repair and rectification of steel castings by metal arc welding process
6409-1971	Code of practice for oxy-acetylene flame cleaning
6916-1973	Code of practice for fabrication welding of steel casting
8002-1976	Recommended procedure for welding of flexible PVC
8004-1976	Recommended procedure for welding of rigid PVC
8455-1977	Recommended procedure for welding of polythlene
8987-1978	Recommended practices for air carbon arc gouging and cutting
9006-1978	Recommended practices for welding of clad steels

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